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HAZUS
Getting Back to Business

Brian B. Quinn

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Where will you be when disaster strikes? Modeling scenarios can help managers ensure that employees can get home, or back to work, after an earthquake or other catastrophe.

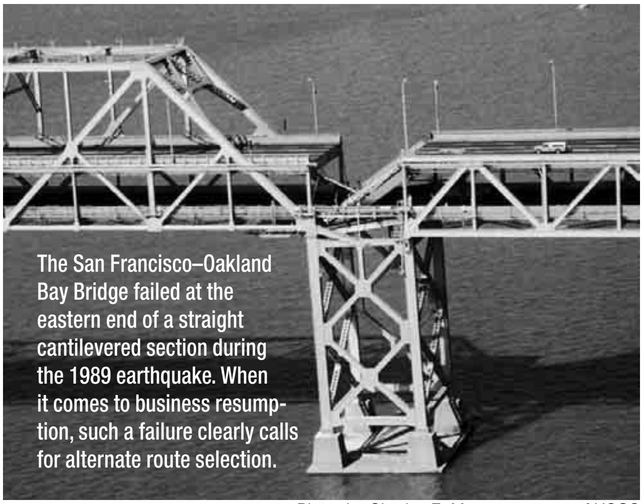
The San Francisco–Oakland Bay Bridge failed at the eastern end of a straight cantilevered section during the 1989 earthquake. When it comes to business resumption, such a failure clearly calls for alternate route selection.

Photo by Charles E. Meyer, courtesy of USGS

A faint rumble is followed by a staggering jolt. The building heaves, books rain off the shelves, and the cubicles are filled with panicked screams.

When disaster strikes, the ability of a business to return to operation depends substantially on how well that company has planned its response strategies and documented the steps required to get back to business at its various locations. To accomplish this, some larger companies employ professionals in risk assessment, disaster response, and business recovery planning.

By combining GIS function and value with loss estimation methodology, BPC professionals can add spatial value to business recovery plans with support for plan writing, evacuation planning, and improved employee awareness about hazards. GIS supports risk calculations that drill down past the public awareness level of regional scientific studies to analyze risk at the building level. And another tool, HAZUS, offers a methodology and regional foundation for more detailed analysis.

Brian B. Quinn implements HAZUS and GIS applications for Charles Schwab & Co., Inc. in San Francisco, California. Quinn has been applying geophysics, GIS, and remote sensing since 1989.

Gotta model it? Get HAZUS

A GIS-based, nationally consistent, loss-estimation methodology created by NIBS through FEMA funding, HAZUS estimates earthquake losses from building inventory data at census-tract level and provides point loss estimates for specific facilities like hospitals, fire and police stations, schools (serving as shelters for the displaced), and bridges. An extension of certain aspects of a broader system called CATS, HAZUS was originally released in 1997 and updated in 1999.

Users select HAZUS scenario events in three ways. Historical epicenters can be selected and replayed to consider the effect they would have on 1990s infrastructure. HAZUS users can also choose a fault from maps and analyze a maximum credible event. And, those with geological knowledge can specify arbitrary fault parameters and evaluate scenario events with magnitude between 5.0 and 8.5.

A company's HAZUS implementation can incorporate its office structures into the HAZUS building inventory if some construction details are known. With GIS tools, company resources (people, headquarters, warehouses, service centers, and employee home addresses) can be overlaid with HAZUS estimates of casualties, building and bridge damage, and hospital functionality — on a scenario by scenario basis.

A HAZUS GIS in the company's BPC group can likewise facilitate information sharing with local government emergency management agencies to improve response planning.

Glossary

BPC: Business process continuity

CATS: Consequences Assessment Tool Set

ERT: Emergency response team

FEMA: Federal Emergency Management Agency

HAZUS: Hazards U.S.

NIBS: National Institute of Building Sciences

USGS: U.S. Geological Survey

Shaking up the data

Though HAZUS is available as a free add-on for two GIS programs, some businesses may want to obtain supplemental multihazard data for several states. The first state's data is included with HAZUS, and NIBS offers supplemental data for a small fee per additional state. Because soils quality data are an important part of earthquake loss estimation, they are also used when available, along with maps describing water depth and susceptibility to liquefaction and landslides.

But such data are hard to acquire. To this end, regional HAZUS user groups have been formed to bring together people from all levels of government, busi-

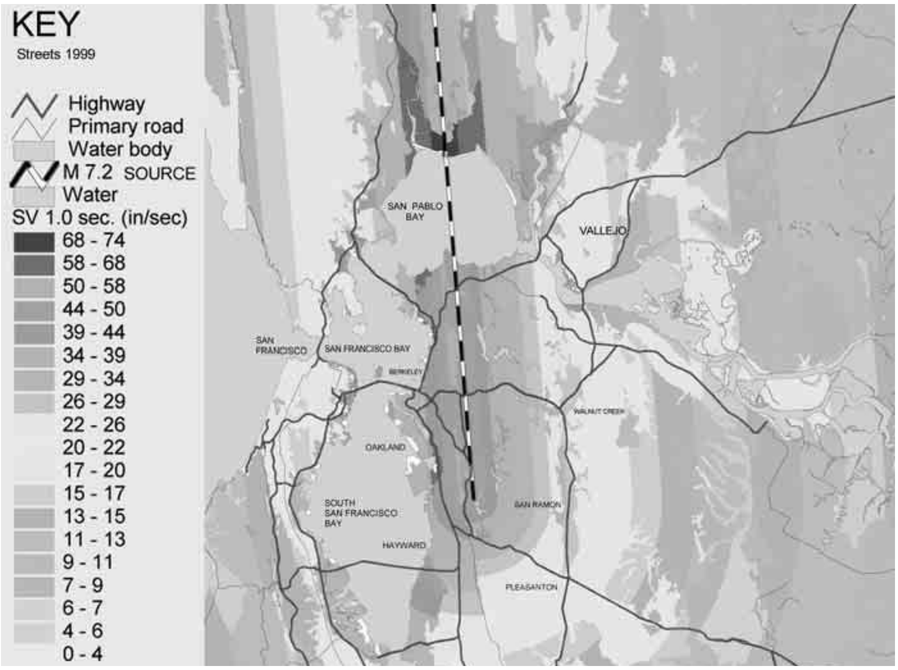

FIGURE 1 Ground motion estimated for a HAZUS scenario in which the northern Hayward and the Rodgers Creek faults rupture together to produce a magnitude 7.2 event. HAZUS estimated ground displacement, velocity, and acceleration, on a 250-meter grid. Shown here is 1.0-second period spectral velocity for the area around the San Francisco Bay, San Pablo Bay, and Sacramento/San Joaquin River deltas. The black/white band is the scenario source, and the complex pattern of ground motion shows the amplifying effects of soil types.

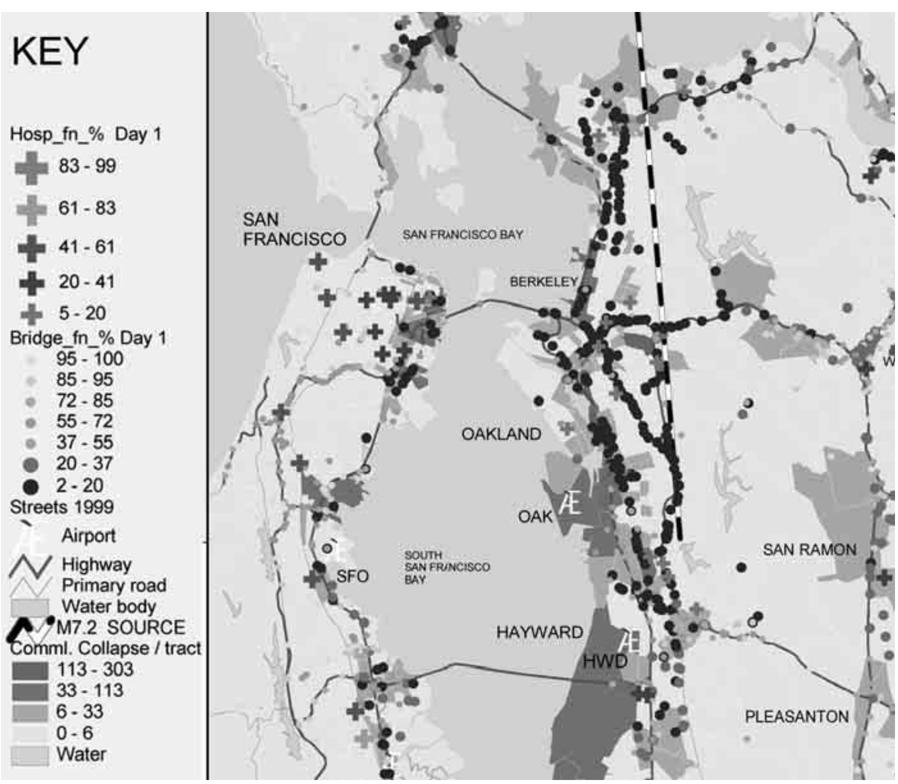

FIGURE 2 The estimated collapses of commercial buildings per census tract for the Hayward–Rodgers Creek scenario are overlaid with icons showing estimated hospital and highway overpass functionality one day after the event. Census-tract estimates use soil type at the tract centroid. Hospital and bridge function is based on soil type at the structure's location.

ness, and academia to improve data and distribute it to users.

The San Francisco Bay Area HAZUS User Group is one such organization and has been developing event models using HAZUS in conjunction with 1:250,000 soils data from the California Division of Mines and Geology. A scenario can be summarized with loss reports and maps of interest to emergency responders in the hours after an event. Recently, a Hayward–Rodgers Creek earthquake has emerged as an important plausible event, and a magnitude 7.2 scenario (body wave) was used to demonstrate some HAZUS analytical results.

Figures 1 through 5 show estimated ground motion and expected losses for this Hayward–Rodgers Creek scenario. The black-and-white stripe in each figure marks the location of the HAZUS source, a linear feature slightly east of the surface expression of the Hayward fault. North of San Pablo Bay, the source is slightly west of the Rodgers Creek fault and models a linear rupture connecting two slightly skewed faults.

Figure 1 plots spectral velocity of a 1.0 second period, a component of ground motion that is very destructive to buildings. Because some soil conditions can amplify ground motion, localized areas in San Francisco show relatively stronger shaking. In particular, the city's Marina district on the north side and Mission Bay on the east side show stronger shaking than nearby hilly areas.

Figure 2 displays census-tract detail estimates of complete commercial building collapses as well as estimated highway bridge and hospital function one day post-event. In the worst-hit areas, the HAZUS estimate of complete damage reaches 300 collapsed commercial structures per tract. The map also indicates that many bridges, including mass-transit structures, are expected to function below 20 percent the day after the event. Likewise, hospitals in the most severely damaged areas of Berkeley and Oakland are expected to function below 20 percent capacity.

Figure 3 displays one of the consequences of building collapse. Estimated deaths for a 2 PM event reach from 17 to 74 per tract in the most damaged areas. Bridge and hospital function are also shown for three days after the event to illustrate the ongoing correlation among casualties and impacted transportation links. Casualties per tract are high in San Francisco's financial district and San Mateo County's Oyster Point. Also hard-hit are the east bay industrial districts in Hayward as well as the area around the Oakland airport.

Figure 4 displays some of the region's housing diversity with an economic proxy and compares that with concentrations of casualties from the scenario. Tract-level data from 1990 are plotted in shades of deepening green for higher median home values. Estimated deaths and life-threatening injuries by census tract are also overlaid as dot densities. The highest concentrations of casualties are visible in the San Francisco and Oakland downtown areas, as well as in Berkeley.

Figure 5 extends the view to the difficult days following the event. Estimates of school functionality (considering their use as shelters), one day post-event, are shown with dot density plots of estimated displaced households (20 households per red dot.) For reference, the location and size of emergency operations centers are plotted from the HAZUS inventory data.

From the magnitude 7.2 Hayward–Rodgers Creek scenario used in these figures, a HAZUS summary report listed estimated losses across a 14-county area. HAZUS predicted 700 deaths, almost 50,000 collapsed buildings, more than 100,000 displaced households, and about $55 billion in property and business interruption losses following the scenario. In addition, HAZUS calculated that approximately 45 debris megatons of concrete, steel, wood, and masonry would be generated from building damage. Were this material not recycled into reconstructed buildings, it could represent a mass approaching a decade's typical contribution to the region's landfills.

Settling back in

The modeled Hayward-Rodgers Creek event illustrates how HAZUS works to provide valuable information for emergency response. But, it presents just a single scenario. Business planners need to identify which events would have the greatest impact on their operations, so several models should be completed to understand how to minimize potential impacts.

The Charles Schwab BPC team runs HAZUS scenarios, exports results, and com-

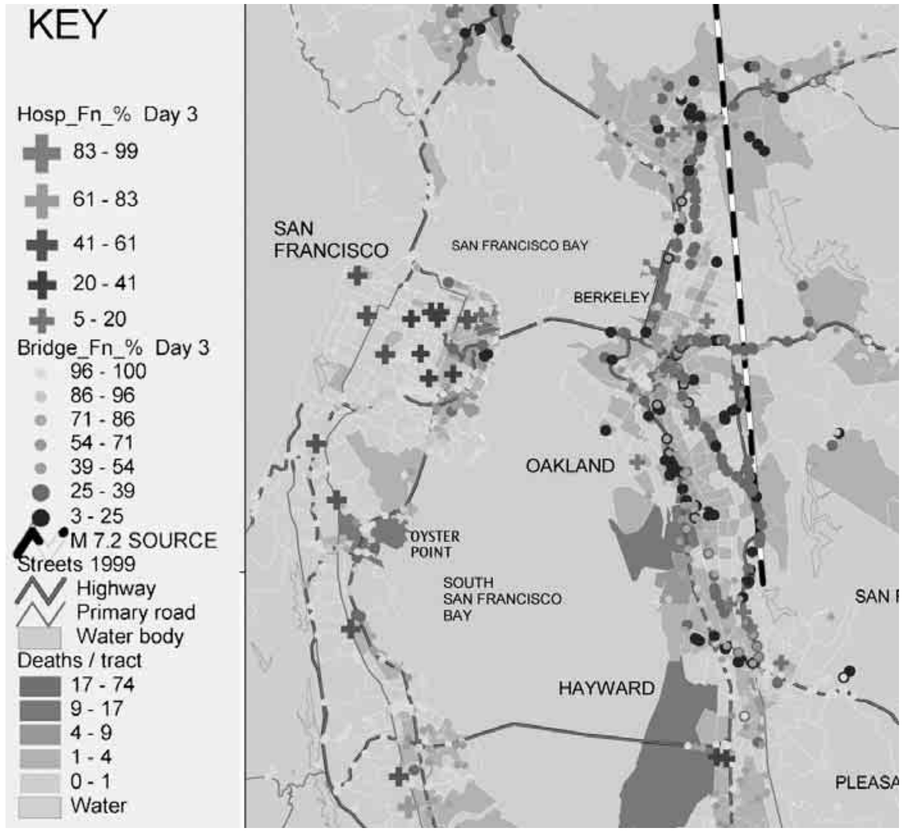

FIGURE 3 Also based on the Hayward–Rodgers Creek scenario, this view shows the HAZUS-estimated deaths per census tract overlaid with expected hospital and bridge functionality values three days after the event.

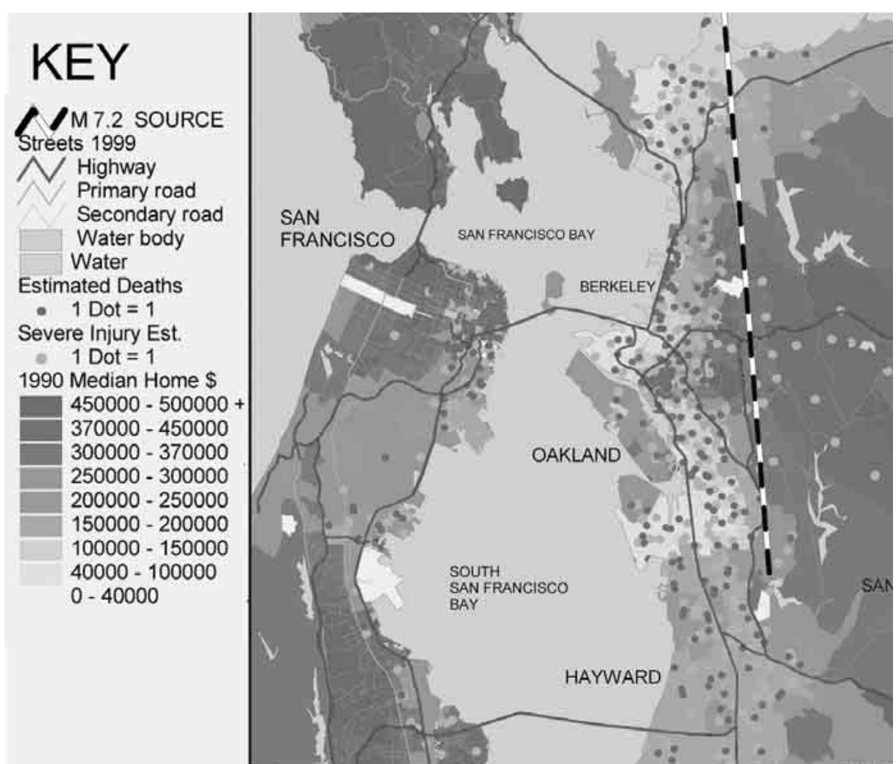

FIGURE 4 To contrast casualties and affected population, this map overlays 1990 median home values by census tracts with estimated severe injuries and deaths. The more costly homes are shown in deeper green, and dot densities depict concentrations of casualties.

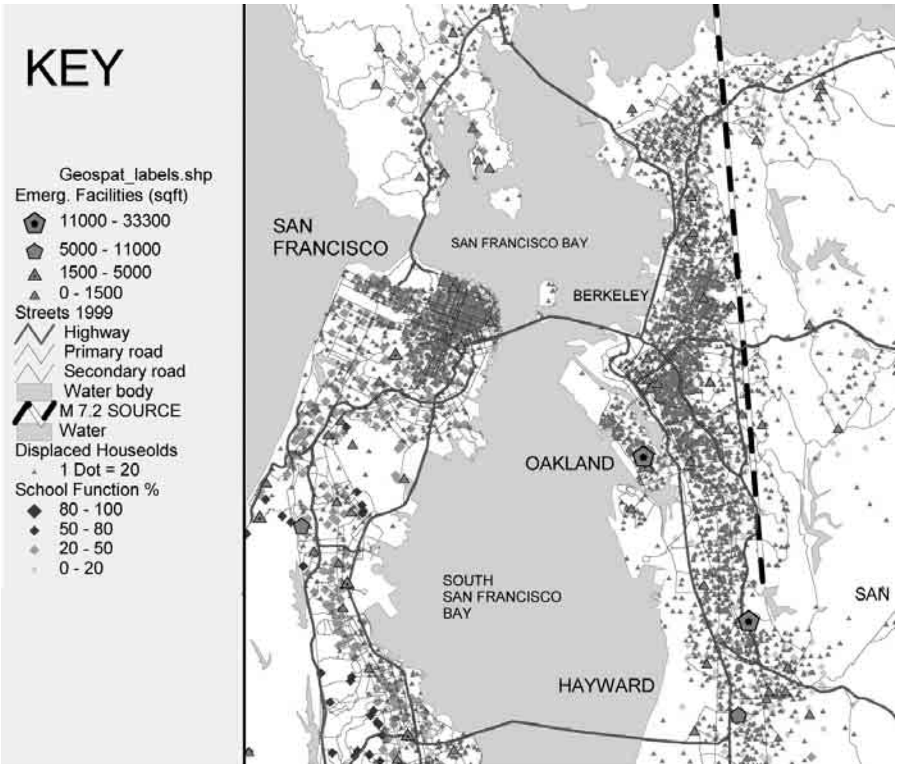

FIGURE 5 To compare shelter needs with availability, this view plots predicted functionality of schools (potential shelters) with tract-level estimates showing displaced households and sizes of emergency facilities. Overwhelmed shelters can suggest needs for mutual aid in response to the Hayward–Rodgers Creek scenario.

piles user maps in a GIS viewer program. Because internal business units within the company prepare recovery plans for generic worst-case scenarios, these HAZUS maps help provide some realizations of what worst-case events might really mean. HAZUS scenarios can show impacts on specific employee teams when home addresses are geocoded and overlaid with predicted losses.

The company's BPC team has been particularly successful in engaging employees with HAZUS results by combing the maps with USGS 1-meter digital ortho-photo quarter-quads. Parcel level basemaps and submeter orthoimagery likewise give us a framework to bring hazard, employee home-to-work routing, and lifeline information from the region through the city and to the walls of our buildings. Within structures, the BPC team has also used GIS to provide context for floor plan layout drawings owned by Schwab's facilities department.

Emergency response teams. At Charles Schwab, we employ our implementation of HAZUS to provide information to our ERTs. ERTs are responsible for establishing emergency command centers, drilling participants in emergency response operations, and maintaining contact with employees at regional offices or at their homes after-hours. Typically these teams are organized with a lead and alternate leader.

For an ERT member to participate in a response event, he or she must be informed of the event and available for response. After an earthquake, ERT members may be unavailable because they are injured, are out of communications or transport reach, or have vital concerns regarding their own household's well-being.

To mitigate these exposures, GIS helps make ERTs more resilient by providing information that enables teams to select alternate responders exposed to different faults than the primary leaders. HAZUS scenario results, for instance, can clarify how two households, 20 miles apart but along the same fault, can have very similar impact from the same scenario event, while two others a similar distance apart, but perpendicular to the fault, may leave one household relatively unscathed.

Street layers are often added to HAZUS scenarios in the Schwab implementation to provide context and clarify the impacts on transit. Recent street data has been worth the cost in regions where team members live or work in new developments and could not otherwise be geocoded. Some critical employee teams have had their home addresses geocoded and overlaid on custom scenario maps. With the information, consequences of loss of bridge functionality are illustrated to provide ERT members with alternate routing options to work.

Serving it up. Currently, Charles Schwab is developing a map service that will permit internal business units to access HAZUS scenarios and data through an intranet. When it comes to sharing the BPC spatial information, though, users oppose having mapping applications on their computers, and they do not have time for training. It is enough work keeping recovery plan documents updated.

With more than 100 business units, the time spent creating well-focused static maps for each business unit's plan can be better spent creating an interactive maps service. This browser-based service is being devel-

Web Sites to Check Out

For more information about HAZUS, visit

- FEMA's HAZUS page, www.fema.gov/hazus
- NIBS' HAZUS site, www.nibs.org/hazus.htm
- San Francisco Bay Area HAZUS User Group, www.hazus.org

To learn more about earthquakes and geology, see

- USGS's Earthquakes page, http://earthquakes.usgs.gov/
- National Earthquake Information Center, http://neic.usgs.gov/

For California seismic hazard and soils data, link to

- California Division of Mines and Geology, www.consrv.ca.gov/dmg/

To obtain details about CATS, upload

- www.saic.com/business/solutions/natsec/cats.html
- www.esri.com/news/arcnews/fall99articles/07-catsemer.html

To find out more about business recovery preparation, contact

- Business Recovery Managers Association in California, www.brma.com oped for BPC plan writers, ERT members, and other internal users. With the service, ERT leaders, for instance, will be able to gather their team members' home addresses (or download them from a secure human resources directory), browse the BPC map service, geocode the addresses, and then overlay the data on three to six HAZUS scenarios to glimpse patterns for several possible earthquakes.

If the BPC intranet map service proves effective, some parts of it may be rolled out to all employees to extend the BPC group's employee awareness activities. HAZUS scenario results, if transparent enough, can clarify patterns of expected damage to neighborhoods, school and work routes, and the workplace itself. In this way, the BPC map service will seek to serve hazard information to concerned persons at their convenience and at their desired level of detail so that they can make good decisions on their own.

d G. Wilshire, courtesy of USGS

During the 1989 temblor, California Highway 17/Interstate 880 along Cypress Avenue in Oakland collapsed. This viaduct was not rebuilt.

Beware of future HAZUS

GIS can be a powerful tool for business resumption planning following a disaster. With the introduction of HAZUS for earthquake modeling, companies have been further empowered to prepare for emergencies. Developments are also underway to create HAZUS flood and wind loss estimation modules and increase the resolutions of the inventory data, expanding HAZUS capabilities even further. In addition, 1-meter panchromatic and 4-meter color satellite data seem poised to become relevant to BPC planning and may already be desirable for large companies' disaster response efforts.

Beyond emergency response and recovery planning, HAZUS and BPC efforts can together even introduce a business to focused GIS products, catalyzing broader GIS uses throughout a company.

Acknowledgments

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Manufacturers

NIBS and FEMA offer HAZUS for free in both a **MapInfo** (www.mapinfo com) Professional 5.5 and **ESRI** (www.esri.com) ArcView 3.2 format. **Charles Schwab Co.**(www.schwab.com) typically employs the MapInfo HAZUS for scenario analysis and creates user maps in ArcView. The company also makes use of ESRI's ArcView StreetMap 2000 and ArcView Network Analyst extension. For Web site development, BPC staff employ ArcInfo 8, ArcSDE, and ArcIMS, and, to process satellite imagery, they utilize ERDAS IMAGINE Advantage software from **ERDAS** (www.erdas.com). HAZUS default building inventory data is derived from aggregations of 1996 **Dunn & Bradstreet** (www.dnb.com) commercial square footage data. ⊕